3.0 INJURY DETERMINATION AND QUANTIFICATION

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3.0 Injury Determination and Quantification

Three threshold requirements identified in the Oil Pollution Act must be met before restoration planning can proceed: 1) injuries have resulted, or are likely to result, from the incident; 2) response actions have not adequately addressed, or are not expected to address, the injuries resulting from the incident; and 3) feasible primary and/or compensatory restoration actions exist to address the potential injuries (15 CFR § 990.42). Information collected by the Trustees and the Company during the preassessment phase for the Incident satisfies the three criteria listed above and confirms the need for restoration planning to address impacts from the Incident (AR #2).

This chapter describes and quantifies the natural resource injuries resulting from the Incident. The chapter begins with an overview of the types of information and data collected during the preassessment phase of the damage assessment process, followed by a description of the Trustees' strategy to identify and quantify specific injuries to natural resources.

3.1 Summary of Preassessment Activities

Within a few days of the Incident, the Trustees and the Company initiated a preliminary investigation of the impacts of the Incident on the natural resources in the area. The preliminary assessment focused on collecting perishable or ephemeral information necessary to evaluate the fate and transport of the gasoline and potential injuries to natural resources (AR #2). These activities were coordinated with and complemented information and data collected by the response agencies. The results of the preassessment evaluation are summarized in the Whatcom Creek Incident Preassessment Data Report, dated April 20, 2000 (AR #2).

The following activities, conducted by the Trustees, the Company, and/or the response agencies, were used to help evaluate the potential impacts of the Incident on natural resources. Based on the following information, the Trustees believe the Incident caused significant resource injuries to stream biota, riparian and upland habitats, and recreational uses of the resources:

1. **Ground and Aerial Photographs and Video Records**—A comprehensive set of aerial and ground photographs and videotapes was collected to delineate the burn zone (AR #98) and to document the response, assessment, and emergency restoration efforts.

2. **Fingerprinting of Contamination**—Samples of gasoline collected from the pipeline were chemically analyzed. The results of these analyses were compared to analytical results from biota, sediment and water samples in order to confirm that the contamination of these resources came from the Incident. Samples of gasoline were also analyzed to better understand the potential toxicity, rate of degradation, fates, and persistence of the spilled material (AR #1, 2).

3. **Collection of Response Information, Toxicity Data, and Literature Search**—The Trustees collected and evaluated reports and documentation generated as part of the

operational response (AR #2, 34). A search was also conducted to collect relevant historical research, management plans and other information regarding the Whatcom Creek watershed. A comprehensive literature review (AR #35-73, 79) and a risk analysis (AR #74) were conducted to assess chemical hazards and potential ecological risk to Whatcom Creek organisms from contaminated water and sediments. Finally, literature searches were collected on the fate and effects of similar spills (AR #75-77), and the effects of fire on riparian and stream habitats (AR #128-133).

4. **Documentation of Fish and Wildlife Mortalities**—Collection and recording of dead fish and injured wildlife began the day after the Incident. A formal fish kill assessment (AR #33) was conducted to assess the number of dead or moribund organisms (fish, amphibians, etc.) due to the Incident (AR #10). Survey correction factors were also considered to take into account fish and wildlife that were killed but not found (AR #33, 78, 80, 84). Surveys were conducted in the burn zone to enumerate terrestrial wildlife injuries and determine the loss of wildlife habitats (AR #85).

5. **Water Quality Studies**—Permanent water sampling stations (Figures 12, 13) were established in the Creek and in Bellingham Bay (AR #2, 15, 86). These stations were repeatedly sampled in the months following the Incident to determine whether gasoline was still present and the rate of degradation of the gasoline. One of the response actions was to agitate sediments using mechanical equipment during the day and then flush the stream nightly by increasing the flow from Lake Whatcom. Water samples were collected during nightly flushes to evaluate potential effects and success of the instream remedial restoration efforts. Water samples were also collected to determine potential input of contaminated soil and combustion products during rainfall events.

6. **Characterization of Sediments and Sediment Pore Water**—Samples of the streambed sediments and interstitial water (water among sediment particles) in the streambed gravels were collected (Figure 24) from twelve stations between the outlet of Lake Whatcom to below Interstate 5, including known salmonid spawning areas near Woburn and Racine streets (Figure 14) (AR #2, 15). Stations were sampled before and after remedial efforts to document the efficacy of the streambed remedial efforts. The samples were also analyzed to identify the location and potential severity of contaminated "hot spots" and to determine the risk to salmonid eggs and juvenile salmon that reside in the stream gravel.

7. **Stream Invertebrate Studies**—The Trustees coordinated with the Company to evaluate the effect of the Incident on invertebrates in the Creek. Periodic surveys were conducted in the Creek to determine the health, diversity, and recovery rates of the macroinvertebrate community (AR #2, 15).

8. **Stream Temperature Monitoring** A monitoring system was developed to track changes in stream temperatures in Whatcom and Hanna creeks as a result of the fire and loss of shade

canopy. Historical stream temperature data were also researched. Pre-Incident temperature data were found for several stations along the Creek, as well as for Cemetery and Lincoln creeks near their confluences with the Creek. Modeling was conducted to determine the potential temperature elevations that might occur as a result of the loss of shade (AR #2, 15).

9. **Stream Habitat Surveys**—Stream gravel was excavated and mechanically agitated to release gasoline trapped in sediments. The physical features and habitats of the Whatcom and Hanna creeks (e.g., gravel size, presence of woody debris, the number and quality of pools, riffles, glides) were assessed and mapped before and after emergency restoration. The objective of the stream habitat survey was to assess the physical habitat conditions available to salmonids before and after emergency restoration to ensure the resulting habitat conditions were at least as suitable for salmonids as prior to the stream work. A computer model, the Physical Habitat Simulation Model (PHABSIM), was used to estimate the amount of available spawning and rearing habitat available pre-and post-emergency restoration in the Creek for various life-history stages of anadromous and resident fish (AR #15, 22).

10. **Vegetation Studies**—In addition to the aerial photography of the burn zone, several surveys and studies were conducted by the City of Bellingham and WDNR to measure the size of the burn zone and to evaluate the survivability of injured trees and large woody vegetation within that zone. Surveys were conducted along the Creek and in the burn zone to assess the historic versus current vegetation status. Studies were also conducted to assess soil structure and erosion potential of the burn zone. Extensive mapping was conducted focusing on non-native vegetation. Follow-on surveys were also conducted to evaluate the efficacy of emergency revegetation and invasive-species control efforts (AR# 100).

11. **Salmonid and Fish Recovery Studies**—Studies were conducted in the fall of 1999 to assess the escapement of adult salmon into the Creek and their spawning success. Snorkel and beach seine surveys were conducted in the spring and summer of 2000 to determine the abundance and condition of juvenile salmonids and resident fish in the Creek and adjacent tributaries affected by the Incident (Figure 15) (AR #87).

12. **Source Site Characterization and Remediation**—Soils at the pipeline break were contaminated and gasoline percolated into the ground water. A detailed study was conducted to determine the extent of the soil and groundwater contamination (AR #88, 89).

13. **Park and Recreational Use**—The Incident not only injured an ecologically sensitive area, but also impacted important recreational lands. Closures of the Park and other public facilities were documented (AR #11, 90) and preliminary estimates of lost visitation were developed. The Trustees prepared a timeline of the reopening of park sections (AR #2). Recreational fisheries were also affected, and the Trustees kept track of the location and duration of fishing closures. Other related resource injuries, including passive-use losses and future losses, are identified and discussed in the Preassessment Data Report (AR #2).

14. **Preassessment Modeling of Fates and Marine Injuries**—Preliminary modeling of the potential fates of the gasoline and potential for injuries to natural resources in Bellingham Bay was performed using the SIMAP (Spill Impact Map) model developed by Applied Science Associates. SIMAP is a computer model that estimates the physical fates and biological effects of releases of oil and hazardous chemicals (AR #91).

15. **Collection of Press Releases, Fact Sheets, Newspaper Articles, and Internet Information**—The Incident generated intense local, regional, and national media attention. A number of informational Internet web sites were also developed by Whatcom County, the City of Bellingham, the *Bellingham Herald*, the Company, and others. The Trustees collected and archived media reports and Internet information on the Incident (AR #93-97).[15] This information was used to help understand community priorities and concerns about the affected areas. The Trustees also used some of the early press releases and fact sheets to understand the sequence of events of park closures and re-openings, and other restrictions on public uses. Finally, many photographs of the Incident were collected from Internet sites.

3.2 Assessment Approach

The goal of injury assessment under the Oil Pollution Act is to determine the nature and extent of injuries to natural resources and services that will provide a basis for evaluating the need for and type and scale of restoration actions. The assessment process is a two-step process: 1) injury determination and 2) injury quantification.

Injury determination begins with the identification and selection of potential injuries to be investigated. In accordance with Oil Pollution Act regulations, the Trustees considered several factors when making this determination, including, but not limited to, the following:

- The natural resources and services of concern;
- The evidence indicating exposure, pathway and injury;
- The mechanism by which injury occurred;
- The type, degree, and spatial and temporal extent of injury;
- The adverse change or impairment that constitutes injury;
- Availability of assessment procedures and their time and cost requirements;
- The potential duration of the natural recovery period; and
- The scope of feasible restoration actions.

[15] Because of the large volume of Internet and media reports on the Incident, the Trustees' archive of information is not comprehensive.

The Trustees and the Company shared a common goal of implementing restoration as quickly as possible, and therefore they did not pursue expensive, multi-year injury studies but instead focused on designing and implementing emergency restoration and long-term restoration planning which would more expediently benefit the resources. Consistent with Oil Pollution Act regulations, the Trustees used procedures such as focused site investigations, surveys, field sampling, consultation with experts, and review of relevant scientific literature to document exposure and demonstrate injuries to natural resources and services.

3.3 Summary of Preassessment Findings

The following section briefly summarizes the key results of the preliminary studies. More detailed information can be found in Section 3.4 of this draft RP/EA, in the Preassessment Data Report (AR #2), the Company's Emergency Restoration Plan (AR #1), and the Company's draft Long-Term Restoration Plan (AR #15).

Gasoline Fates—The pipeline break resulted in the release of an estimated 236,000 gallons of gasoline (AR #3). The exact fates of the gasoline are unknown but a large fraction was consumed in the fire or evaporated. Smaller amounts dispersed in the turbulent creek waters or remained on the surface in the form of sheens on Bellingham Bay. Some of the gasoline saturated the ground, geologic formations surrounding the break site and adjacent soils, and slowly seeped into Hanna Creek (AR #88, 89).

Gasoline Characteristics and Weathering—The product released from the pipeline was a typical automotive gasoline. This product is a colorless to yellow liquid with a strong petroleum odor. Chemically, gasoline consists primarily of monoaromatic hydrocarbons, also referred to as BTEX (benzene, toluene, ethylbenzene and xylene). Gasoline also has some heavier diaromatic hydrocarbons such as naphthalenes. Gasoline is lighter than water, has a high vapor pressure and a very low viscosity. As a result, it floats and spreads rapidly when spilled and readily evaporates. Following spillage, the more volatile BTEX constituents rapidly volatilize into the atmosphere and, to a lesser extent, dissolve into the water. Thus, while gasoline is considered highly toxic, most of the gasoline-range hydrocarbons have a relatively short persistence in surface waters. However, some of the slightly heavier hydrocarbons can persist and provide a source of contamination. The rate of evaporation, dissolution, and degradation are dependent on factors such as local environmental conditions, mixing, and temperature. Evaporation and burning removed most of the spilled surface gasoline, but the gasoline contamination in the groundwater and sediments provided a low-level, but long-term, source of hydrocarbons.[16]

Impacts to Surface Waters—Short-term water quality in the Creek was adversely affected during the Incident. The combination of the fire and toxic levels of hydrocarbons killed virtually all aquatic biota from the spill site to the mouth of the Creek (AR #10). Emergency activities

[16] Information in this section is based on a number of sources, including AR #2, 15, 42, 43, 73.

conducted by the Company included: 1) agitation of the stream bed surface to remove volatile hydrocarbons attached to surface materials; 2) pulsed flushing flows following daily bed agitation; 3) removal of mobile pieces of debris with the potential for retaining adsorbed hydrocarbons; and 4) mechanical flushing of local areas (AR #1). Hydrocarbon levels decreased markedly following the Incident and direct long-term effects on surface water quality were not detected (AR #15).

Marine Impacts—The potential for marine impacts was evaluated using a combination of modeling and field data. Modeling was performed using the SIMAP model (AR #91). The spill was treated as a subsurface release at the point where the Creek enters Bellingham Bay. The potential effects were evaluated using a database that has average biological abundances for marine fish and invertebrates in Puget Sound. The model showed that contamination was restricted to Bellingham Bay and remained approximately four to five days after the Incident. The acute toxicity was restricted to the area near the Creek mouth. The pattern of this contamination is in agreement with the observations of the sheens and field measurements of contamination conducted jointly by the Trustees and the Company (AR #15, 86). The model predicted short-term and localized mortality of estuarine fish and invertebrates in the Whatcom Waterway.[17] Field observations[18] made immediately following the Incident indicated that direct mortalities to estuarine fish and invertebrates occurred at the Creek mouth and estuary (Figure 16). These mortalities appear to have been short-term and localized. Foot surveys conducted near the mouth of the Creek five days after the release found no sheens or odors, no distressed or freshly dead organisms, and no other indications of a persistent marine impact (AR #99).

Soil and Ground Waters—Characterization of subsurface soil and groundwater in the pipeline release area began on June 16, 1999. Over 115 subsurface explorations were completed to evaluate the lateral and vertical extent of gasoline-related soil and groundwater contamination (AR #88, 89). A free-product and ground water interceptor system (an east-west oriented horizontal drain and vertical recovery well) was installed between the point of release and the Creek to recover gasoline observed seeping into the Creek north of the pipeline rupture location. Over 6,500 cubic yards of gasoline-contaminated soil were removed and treated at a hazardous waste facility. Long-term groundwater monitoring by the Company under the supervision of WDOE will continue on a routine basis to monitor the results of the remedial action, to evaluate the migration of contaminated groundwater beneath the site, and for regulatory compliance.[19]

Wildlife—The Whatcom Creek watershed is utilized by a variety of terrestrial wildlife (Figure 17). The USFWS and the WDFW conducted limited surveys of the burn zone to search for dead,

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[17] The Whatcom Waterway is an industrial site currently subject to cleanup under the Washington State MTCA (AR #17).

[18] Dale Davis, Washington Department of Ecology, personal communication.

[19] The requirements for the cleanup of residual gasoline-contaminated soil in the release area and contaminated groundwater and protocols for groundwater monitoring are embodied in the WDOE's MTCA Regulations (WAC 173-340).

moribund, or injured wildlife following the fire (AR #10, 85). The scope and extent of wildlife surveys to assess impacts to terrestrial species were deliberately limited within the burn zone to reduce additional impacts to riparian habitat by survey crews. It was also evident that it would be extremely difficult to find and enumerate the variety of animals that would likely have been present in the burn zone. Consequently, there are no complete estimates on the species and numbers of animals killed. Although observations of direct mortalities were limited, crews observed dead beavers, river otters, small mammals, birds, and reptiles in the days following the Incident (AR #10, 85). The impacts to terrestrial and riparian vegetation from the Incident resulted in a significant and long-term loss of wildlife habitat.

Freshwater Biota (Finfish, Amphibians and Invertebrates)—Direct mortalities occurred to aquatic organisms within Whatcom and Hanna creeks. Aquatic life was most heavily impacted, with over 100,000 fish, aquatic invertebrates (e.g., crayfish), and amphibians (e.g., frogs and salamanders) collected or observed dead (AR #10). Fish losses included juvenile salmonids (coho, chinook, chum, sockeye salmon, and steelhead, rainbow and cutthroat trout), juvenile lamprey, and a variety of other species. In addition to the large fish kill, aquatic macroinvertebrates that serve as important food sources for the fishes were impacted. Aquatic flora, including algae, mosses, diatoms and aquatic vascular plants were also impacted (AR #10). Due to the time of year, adult anadromous salmonids were not present in the stream during the Incident (Figure 18).

Impacts to Stream Habitats—In addition to mortality of stream biota, the Incident and resulting response actions also disturbed the physical features of Whatcom and Hanna creeks. Although many of these features were restored by emergency restoration actions, there was a temporary loss of stream habitat. Hanna Creek was dewatered for several months following the Incident to allow for excavation of contaminated sediments and soils (Figures 19, 20). Approximately 2,000 cubic yards of gasoline-contaminated soil were excavated from the upper portion of Hanna Creek and the lower 800 feet of Hanna Creek was remediated using a combination of soil aeration and agitation followed by soil washing (AR #1). Gravels in Whatcom Creek were mechanically reworked to facilitate release of trapped hydrocarbons. Contaminated natural woody debris was removed from both creeks.

Large Woody Vegetation—Burned terrestrial vegetation totaled approximately 26 acres, including approximately 16 acres of mature riparian forest within the Park and approximately 10 acres of third- or fourth-growth floodplain forest and open lot below the Park. Loss of trees was high within the burn zone and removal of understory crown was nearly complete (AR #98). The loss of cover increased the risk of spread of invasive species into an area that historically had very little problem with invasive species (AR #1, 15, 100).

Park Resources—Recreational services were curtailed throughout a large portion of the Park during the weeks immediately following the Incident. These curtailments in services were reduced through progressive re-openings, with the exception of a continuing closure of the area

within the burn zone (AR #11). As of March 2002, the closure areas in the Park are limited to the Whatcom Creek gorge from the confluence of Whatcom Creek and Hanna Creek downstream to Woburn Street to protect new vegetation, minimize the potential for erosion, and protect public safety.[20] A portion of the Park above the gorge is also closed to help restrict access to the gorge. Services lost include direct uses such as hiking, jogging, biking, horseback riding, swimming, fishing, picnicking, bird watching, nature study, education, photography, drawing, painting, nature enjoyment, and other outdoor activities. In addition to direct use losses, the Incident caused losses to passive uses of the park, i.e., those associated with the simple existence of the Park and the Creek and the natural resources they support. Finally, the Trustees believe the Incident will result in future direct and passive-use losses as a result of the continuing closures.

Fishing Closures—The Creek serves as a popular fishing resource and the Incident occurred during the summer trout fishing season. The WDFW instituted an emergency rule on June 18, 1999, closing all fisheries in the Creek and its tributaries, from Lake Whatcom down to Bellingham Bay (AR #101). These emergency closures remained in effect for 120 days. Additional harvest restrictions on salmon and other game fish were put into effect on November 19, 1999 (AR #102).

3.4 Injured Natural Resources and Resource Services

The Trustees reviewed the results of the response actions, emergency restoration projects, and preliminary assessment studies and determined that injuries to natural resources resulted from the Incident. The response and emergency restoration actions, while beneficial, did not completely compensate for the losses from the Incident. This section discusses five categories of natural resources and resource services the Trustees have determined were injured and require additional restoration measures. The injured resources and services considered by the Trustees include:

1. **Vegetation**—Riparian and terrestrial vegetation;
2. **Water Quality**—Surface and ground waters;
3. **Fisheries**—Anadromous and resident fish, stream invertebrates, and their habitats;
4. **Wildlife**—Birds, aquatic and terrestrial wildlife, and their habitats; and
5. **Human Uses**—Park and fishing closures.

These injuries and the need for restoration for each category of injury are described in more detail below. Proposed restoration alternatives for these injuries are summarized in Section 4.5 and discussed in detail in Chapter 5.

[20] Clare Fogelsong, City of Bellingham, personal communication.

3.4.1 Riparian and Terrestrial Vegetation

The riparian zone is the interface or linkage between the upland (terrestrial) zone and the deep-water (aquatic) zone. Riparian and wetland ecosystems are important islands of diversity within extensive upland ecosystems and provide an important functional linkage between aquatic and terrestrial ecosystems (AR #103). Healthy riparian vegetation provides habitat for wildlife and invertebrates, stabilizes the shoreline and controls erosion, helps maintain water quality and stream stability, and provides shade to regulate creek water temperatures. The vegetation also provides recreational and aesthetic benefits. The Incident heavily impacted this zone and the adjacent uplands.

Three types of impacts to vegetation were anticipated: 1) direct mortality of vegetation, 2) increased potential for erosion, and 3) colonization of the burn zone by invasive plant species. Several studies were conducted by the Trustees and the Company to evaluate the vegetation injuries, and emergency restoration actions were implemented to reduce and compensate for these injuries.

Direct Mortality—The dominant and most apparent injury in the riparian zone and nearby upland zone was the loss of the trees and vegetation. The primary injury pathway resulted from the fire rather than a toxicological response from the gasoline released during the rupture (AR #2). Surveys of the area show that the fire destroyed a total of 2.5 miles of riparian vegetation along both banks of the Creek (Figures 21, 22). The WDNR collected coordinates of the burn perimeter with a differentially corrected global positioning system (GPS) receiver. The area exposed to fire was approximately 16 acres in the Park and 10 acres below Woburn Street (AR #2, 98). The response, excavation, and cleanup activities resulted in several acres of additional injury to vegetation near the break site and along upper Hanna Creek (AR #2).

Several studies were conducted by the Trustees and the Company to evaluate the pre-Incident conditions of the plant communities present within the limits of the burn zone along Whatcom and Hanna creeks. Both historic and current on-site information were collected for these purposes. These studies helped to understand baseline plant communities and the injuries from the Incident in order to scale restoration and monitoring activities. Four basic vegetation classes were evaluated: 1) evergreen-dominated mature second growth forest, 2) deciduous-dominated closed canopy forest, 3) deciduous-dominated narrow riparian forest, and 4) invasive weed-dominated stands of shrubs and low-growing vegetation.

Erosion—One of the consequences of the destroyed vegetation was the potential for increased erosion and sedimentation (AR #105, 130-132). Increased sedimentation can have adverse impacts to stream habitats and fishery resources (AR #106, 107, 130, 132). Fine sediments can smother eggs, pre-emergent salmon, and invertebrates that reside in the interstitial gravels. Burned watersheds are more prone to erosion than those that are fully vegetated for a number of reasons, including, most particularly:

- Presence of a considerable amount of ash, which is easily mobilized by rainfall and runoff;
- Absence of protective vegetative cover, which normally functions to break up the impact of raindrops, which, in turn, dislodge ash and soil particles;
- Decreased infiltration and increased runoff due to physical changes in the surface soil conditions resulting from the fire; and
- Presence of water-repellent layers within the soil profile (hydrophobicity), which decreases infiltration.

All of the burned areas drain directly into the Creek. Often, the first significant rainfall event after a fire brings a high load of ash and debris downstream. Emergency actions were taken by the Company to reduce erosion, including replanting, restrictions on vehicle and foot traffic, and application of fiber mulch with a tackifying agent (Figure 23). Most of the burn area had an intact layer of decaying organic matter that protected the soil surface. As a result, the only areas that required intensive erosion control were those areas where ground-disturbing activity took place as part of remediation. Post-spill water sampling in the Creek showed some increased sedimentation (AR #5). Fortunately, no significant rainfall events occurred during the summer and early fall after the Incident and no substantial erosion problems were observed (AR #15).

Invasive Species—Invasive plants pose a serious threat to the integrity and productivity of natural systems (AR #100). Many introduced species are better able to exploit disturbances such as fire. Invasive plants can out-compete and prevent the re-establishment of native species (AR #15, 100). Over time, non-native species increase in dominance. The result is sometimes a permanent shift in community structure with a greater abundance of introduced rather than native vegetation. Often the introduced plants have lower habitat value for native wildlife and overall habitat quality, and ecosystem functioning can be impaired. Due to the destruction from the fire and the potential for spreading of invasive species, such as Himalayan blackberry (*Rubus discolor*) and reed canary grass (*Phalaris arundinacea*), a recognized problem along historically modified portions of the Creek, the Company agreed to an extensive effort to prevent invasive plants from gaining a foothold in the burn zone (AR #1). The Company also agreed to implement control measures elsewhere along the Creek. Follow-up surveys have shown that the emergency control measures were successful (AR #100).

Need for Restoration—Recovery has already begun in the burn zone and the emergency restoration has been beneficial in reducing harm and compensating for impacts from the Incident. Ferns and other low plants have started to grow and the planted seedlings are growing. Some of the services and functions provided by the forest, including wildlife habitat, have also begun to recover. However, complete recovery back to pre-Incident conditions will be slow. The seedlings planted since the Incident will take decades to reach the size of the burned trees. Therefore, the

Trustees are proposing that completion of the emergency restoration actions and acquisition and protection of forested lands are appropriate restoration actions under this draft RP/EA.

3.4.2 Surface and Ground Waters

The Incident affected approximately 1.6 miles of streambed in Hanna and Whatcom creeks and influenced water quality and aquatic biota in an additional 1.4 miles of Whatcom Creek downstream of the burn zone toward Bellingham Bay. The total stream length affected is estimated to be three miles.

Surface Waters—Water samples were collected at eight sites along the Creek and at twelve sites in Bellingham Bay to characterize the extent and level of gasoline hydrocarbon exposure in potentially affected areas of the Creek, as well as the decay of the concentrations over time (AR #2, 15). Water samples were taken from the Creek and bay stations beginning on the afternoon of June 11, 1999. High levels were found initially, but levels declined rapidly within the first two days following the Incident (AR #15). Stream sampling continued during the remediation process, and the presence of gasoline was detected as pockets of the spilled product were released. Water flows in the Creek were manipulated to provide low flows during working hours and higher flows at night to assist in flushing gasoline out of the system. Nighttime samples were collected near the lower end of the Creek at Dupont Street in order to evaluate whether and how much gasoline might be released into Bellingham Bay, but no appreciable levels of gasoline hydrocarbons were found (AR #15). During all aggressive remediation activities aimed at freeing product from the streambed, downstream gasoline hydrocarbon levels were at or near non-detection limits, indicating the product likely volatilized quickly after release (AR #15).

Pore Waters—Salmonid spawning habitats were exposed to gasoline and there was concern that gasoline might be trapped in the interstitial water in the streambed gravel and contaminate eggs deposited during the fall and winter spawning events. Known salmonid spawning areas were sampled by placing glass pipettes into the gravel and slowly withdrawing water (Figure 24). Samples were collected before and after instream remediation. Several spawning sites sampled in July 1999 had detectable levels of gasoline hydrocarbons and BTEX. The sites showed significant pore-water decreases in gasoline compounds after remediation but several locations still had elevated levels of gasoline compounds. These sites were re-agitated. Sampling of sites following remediation indicated that streambed agitation was successful in removing gasoline from the stream gravels (AR #15). The Company is developing a sampling plan for sampling fine sediments according to the protocols in the state's Sediment Management Standards (WAC 173-204) to demonstrate that gasoline compounds have been removed from fine sediments as well (AR #15).

Ground Waters—Although the majority of the fuel burned in the fire that followed the release, some fuel entered the soils near the Bellingham water treatment plant. Fuel also infiltrated the bed and bank sediments of Hanna Creek and the bed of Whatcom Creek. Site investigations

included collection of soil vapors, soil, groundwater, surface-water, and water-seep samples. Over 115 subsurface explorations were completed to evaluate the lateral and vertical extent of gasoline-related soil and groundwater contamination (AR #88, 89). A free-product and groundwater interceptor system (an east-west oriented horizontal drain and vertical recovery well) was installed between the release area and the Creek to recover gasoline observed seeping into the Creek north of the pipeline rupture location. Residual gasoline-contaminated soil remaining in the release area will be remediated in accordance with the Washington MTCA (RCW Ch. 70.105D). Long-term groundwater monitoring will be continued by the state regulatory agencies on a routine basis to monitor the results of the remedial action.

Sedimentation—In addition to instream and groundwater contamination, the explosion and fire raised concerns over combustion related contamination and the potential for increased erosion and sedimentation. The primary concern was that a large rainfall event might wash contaminants and unstable soils into the stream. Fortunately, no substantial rainfall events occurred during the summer after the Incident. However, several days of 0.3 and 0.35 inches of rainfall in a 24-hour period were recorded at the local weather station. Analysis of samples during those events showed no observable increases in stream water hydrocarbon levels. Suspended sediment levels were also low, indicating that no appreciable erosion was occurring in the burned gorge areas of Whatcom and Hanna creeks (AR #15).

Need for Restoration—Surface waters returned to their pre-Incident condition after the Incident indicating that the response and emergency restoration efforts were beneficial in controlling sedimentation, intercepting contaminated groundwater, and removing trapped hydrocarbons from the stream gravels. Treatment efforts are continuing in order to intercept the gasoline in the soils and groundwater near the rupture site before they flow into Hanna and Whatcom creeks.[21] While the efforts have been successful, there was an impact to water quality in the system and there is concern for continued seepage. The Trustees are proposing a suite of restoration projects outlined in Section 5 that continue the emergency restoration efforts and protect and create habitat to address injuries to water quality as a result of the Incident.

3.4.3 Fish and Fish Habitats

Prior to the Incident on June 10, 1999, Whatcom Creek supported a diverse suite of fish and other organisms. The presence of multiple-year classes of naturally produced resident and anadromous salmonids and other fishes and invertebrates indicates that this stream was supporting self-sustaining populations (AR #10).

Fish Injury—Spot fires and concerns about worker safety slowed the initial assessment of fish kills (Figure 25). As soon as it was safe to enter the burn zone, scientists representing the Trustees and the Company surveyed Whatcom and Hanna creeks for dead or moribund

[21] This long-term cleanup activity is required by the WDOE MTCA, RCW Ch. 70.105D, and is not a restoration project under this draft RP/EA.

organisms. Five teams of three to six people spent several days collecting and enumerating organisms in each operational stream segment as identified during the response and remediation phase of the Incident. The teams enumerated dead animals and identified all recovered animals. Results of surveys indicate that the Whatcom Creek ecosystem was severely impacted and few, if any, fish and aquatic organisms downstream of the Incident survived.

Virtually all fish and aquatic organisms within the impacted area appear to have been killed. Over 100,000 dead fish and aquatic invertebrates were observed during stream surveys, including 8,842 salmonids (AR #10). Affected biota included several species of juvenile salmonids, including chinook salmon, which are listed as threatened under the Endangered Species Act (50 CFR Part 223, 16 U.S.C. §§ 1531, *et seq.*) (AR #12). Other affected salmonid species included coho, chum, sockeye salmon, resident and sea-run rainbow trout, brook trout, and cutthroat trout.[22] Most of the dead salmonids were fry and smolts. The actual number of fish and aquatic organisms killed from this Incident is probably much higher than that observed by survey crews. Many fish were likely flushed downstream into the mouth of the creeks where they were consumed by gulls and other scavengers or carried away by tides. Other organisms went uncounted because teams could not survey all areas of the creeks due to safety closures, water depth or limited accessibility, or because the fish simply went undetected. Salmonid fry and other small fish are difficult to see and may have been hidden by debris, burned beyond recognition, or in an advanced state of decomposition (AR #33, 78, 80, 84).

Multiple brood years of resident species, such as cutthroat and rainbow trout, were affected. The loss of spawning adult trout and the loss of all juvenile age classes from a major portion of the stream has severely reduced the reproductive potential for these species and will significantly limit the rate of natural recovery in the Creek. For anadromous salmonids, such as steelhead and sea-run cutthroat trout, and coho and chinook salmon, multiple brood years of juveniles were substantially impacted. It will take several generations for fish populations to recover to baseline levels, especially for species listed under the Endangered Species Act. Populations of benthic macroinvertebrates were eliminated in over three miles of stream. These organisms are vital as prey for fish and other species. Recovery of stream invertebrates is critical for the long-term recovery of fish populations.

Temperature Effects—The fire modified the quality of salmonid habitat by reducing shade and increasing water temperatures (AR #15). Additionally, an average volume of over 6,000 gallons per day of groundwater was removed from the watershed for treatment and then discharged through the municipal treatment plant, and therefore was not available for groundwater inflow into salmonid habitats in the stream. Salmonids are sensitive to stream temperatures, and because the Creek is largely fed by surface waters from Lake Whatcom rather than cooler groundwater, the summer water temperatures in the Creek prior to the Incident occasionally reached stressful

[22] Another 15,000 fish, all rainbow trout fry, were killed at the Bellingham Technical College hatchery due to contamination and elevated water temperatures resulting from the fire (AR #10).

levels (AR #15). Field measurements and modeling were conducted to evaluate the additional effects of the canopy loss on stream temperatures and the potential for an increased number of "stressful" days (Figure 27). The worst-case results indicate that loss of riparian vegetation as a result of the Incident increased the 1999 mean daily temperatures of the Creek at Interstate 5 by an average of less than half a degree (0.47°C) during the summer months and had even less of a thermal impact (0.39°C) during the fall months of record compared with that which was predicted to occur under pre-existing canopies (AR #15).

Since 100 percent mortality of aquatic life in the Creek was assumed as a result of the Incident, the estimated temperature increase during the summer of 1999 was not of critical importance to aquatic resources. However, temperature increases were of direct concern during the early fall, when returning adult spawners were in the Creek. Based on the modeling and temperature data, it appears that the lack of a shade canopy increased the number of thermal stress days by two additional days, or a 3.5 percent increase during the first spawning season after the Incident (AR #15). Subsequent years were also modeled to assess the stream temperature recovery as vegetation and shade recovers. Using the conservative assumption that shade would increase only five percent a year, the stream temperatures are expected to return to pre-existing levels (±0.2°C) within approximately four years (AR #15).

Physical Habitats—In addition to the acute mortality, the Incident also resulted in changes to physical features of Whatcom and Hanna creeks (Figures 26, 28). Habitat impacts extended from the spill source downstream to the estuary at the creek mouth, and encompassed all habitat used by anadromous salmonids and lamprey, as well as a significant portion of the stream used by resident salmonids, other fish and invertebrate species. Emergency response actions removed contaminated large woody debris from stream channels and therefore decreased habitat complexity. The gravel cleaning and stream reconstruction efforts also disturbed stream habitats. The emergency restoration efforts mitigated the physical habitat impacts, and the physical habitats in the Creek now are comparable or enhanced compared with habitat conditions prior to the Incident (AR #1). Large woody debris was re-introduced to the Creek and cobbles and gravel were replaced and rearranged to create more pools and increased spawning habitat (Figures 26, 28, 29). Together, these actions have created a stream physiography that is more conductive to fish production (AR #15, 114, 123, 134, 136).

Need for Restoration—There was a significant direct mortality of fish and aquatic organisms resulting from the Incident. In addition, the streambed and adjacent riparian habitats were impacted by the Incident and related remediation actions. Emergency streambed restoration projects have helped to restore the physical features of the streambed to levels that are comparable with or better than their pre-Incident condition; however, the loss of riparian habitat has raised concerns about the effects of elevated water temperatures on recovery. It will take many years for these riparian habitats to recover to full function. Therefore, the Trustees have concluded that the proposed salmonid habitat enhancement projects are appropriate to address the fish injuries. The proposed acquisition and revegetation projects will help to protect and

restore riparian habitats and preserve groundwater infiltration that otherwise would have been lost due to development.

3.4.4 Wildlife and Their Habitats

The Whatcom Creek watershed is home to a number of species of birds, mammals, reptiles and amphibians (AR #7). Wildlife impacts from the Incident include direct mortality, loss of habitat, loss of forage foods and prey, and disturbance caused by remedial activities. Longer-term response efforts also disturbed wildlife that reside in or use the park.

The USFWS, WDFW, and the Sardis Wildlife Center assessed acute impacts. A two-day wildlife survey was conducted starting three days after the Incident (AR #10, 85). The scope and extent of the wildlife surveys to assess impacts to terrestrial species were deliberately limited within the burn zone to reduce additional impacts to riparian habitats by survey crews. It was also evident that it would be extremely difficult to find, enumerate, and identify the variety of animals that would likely have been present in the burn zone. Consequently, there are no complete estimates on the species and numbers of animals killed. Crews conducting stream surveys also noted wildlife impacts. Many of the animals could not be identified by species because of the fire damage. Wildlife collected by survey teams after the Incident included:

- **Birds**—Pigeons, red-tailed hawk, and American dippers
- **Reptiles**—Common garter snake
- **Amphibians**—Bull frogs, red-legged frogs, and salamanders
- **Mammals**—River otter, cottontail rabbit, and unidentified small rodents

Although observations of direct mortalities were limited, it is reasonable to assume, based on the intensity of the fire, that most of the wildlife within the burn zone at the time of the explosion were killed (AR #133). Some animals may have escaped the fire by fleeing or hiding in their burrows, but many of the terrestrial or aquatic animals probably were overcome by fumes and then killed by the fire. Larger animal carcasses were found, but the fire probably completely destroyed many smaller-bodied animals (AR #133).

Need for Restoration—The impacts to terrestrial and riparian vegetation from the Incident resulted in a significant and long-term loss of wildlife habitat. Although wildlife utilization in the watershed is recovering, it will be many years before the impacted area returns to full ecological function. Direct restoration (i.e., restocking) of the affected species is not feasible or appropriate. The Trustees are proposing a suite of restoration projects outlined in Section 5 that continue the emergency restoration efforts and protect and create habitat to address injuries to wildlife as a result of the Incident. The Trustees also anticipate that amphibians and other aquatic wildlife will benefit from the proposed salmonid habitat enhancement projects (AR #103, 123, 136).

3.4.5 Human-Use Services

The Incident directly affected one of the most important recreational resources owned by the City of Bellingham. The Park and the trails along the Creek provide a variety of human-use services including hiking, jogging, biking, horseback riding, swimming, fishing, picnicking, bird watching, nature study, education, photography, drawing, painting, nature enjoyment, and other outdoor activities (AR #2, 7, 8, 19). In addition to direct use losses, the Incident caused losses to passive uses of the Park, those associated with the simple existence of the Park and the Creek and the natural resources they support. Lost, diminished, or impaired human uses of the Whatcom Creek watershed constitute injuries in accordance with the OPA regulations. The loss of human uses (Figure 30) resulted from: 1) the presence and duration of spilled gasoline in the air, water, and soils of the Park and the resulting explosion and fire; 2) the response actions conducted within the watershed that precluded visitation; 3) closure of the area to reduce erosion, allow for vegetation reestablishment, and protect public safety (AR #11); and 4) closure of the recreational fisheries in the Creek to protect recovering fish populations (AR #101, 102).

Need for Restoration—The Park areas are largely reopened, but the burned vegetation is an ongoing reminder of the loss. There has been a significant interim loss of direct and passive uses, diminishment of the value of the Park, and future direct and passive-use losses resulting from the Incident. Therefore, the Trustees have concluded that the proposed land acquisition and park improvements are necessary and appropriate to address the recreational and passive losses. The salmonid habitat enhancement and revegetation projects will also help address the recreational losses.